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SUNFLOWER POWER CONVERSION SYSTEM

QUARTERLY REPORT

SEPTEMBER – NOVEMBER 1962

a division of

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LIST OF ILLUSTRATIONS

I. PROJECT OBJECTIVES

The Sunflower program objectives are to accomplish fabrication, test and development tasks oriented toward confirming the conceptual validity and performance feasibility of a solar-powered 3 kw mercury Rankine power conversion system. Major items include solution to long-term, high temperature lithium hydride containment, demonstration of component operational and endurance integrity, experimental confirmation of the design integrity of the aluminum honeycomb petaline collector, and operational integrity of the integrated Rankine system.

II. PROJECT OBJECTIVES FOR THE REPORTING PERIOD OF SEPTEMBER 1, 1962 THROUGH DECEMBER 1, 1962

Performance checkout and endurance testing of the turbo-alternator units will be conducted in the component test booth as dictated by availability of component hardware.

Initial system flushing and checkout testing will be initiated in a systems test booth on the PCS I-1 system. The objectives of the test will be to obtain operating performance data for all components assembled as a system. After short time performance testing has been accomplished, other test objectives, including endurance testing, will be achieved.

Single panel solar collector testing will be conducted to determine single panel efficiencies with lacquered, vapor-deposited aluminum, and silicon oxide coatings.

Initial vibration testing of the full-scale pre-prototype collector with a simulated structure will be conducted on the MB 210 vibration test equipment. Deployment testing of the full-scale collector will be conducted with pre-prototype rim locking hardware.

Loop testing efforts will consist of completion of the workhorse loop and loop checkout. Initial testing will be conducted on the hydrogen swallowing capability of the jet centrifugal pump.

Work will continue on the fabrication of the mercury corrosion loop which is to be operated for 5,000 hours. Material choices are to be Haynes Alloy No. 25 with miscellaneous portions of Type 316 stainless steel in the low temperature instrumentation readout equipment.

Materials efforts will consist of the evaluation of capsules currently undergoing test, fabrication of new capsules, and completion of the construction of a second static temperature test furnace.

III. PROJECT PROGRESS DURING THE REPORTING PERIOD

PROJECT MANAGEMENT

During the reporting period, discussions continued with NASA regarding redirection of the Sunflower program. Items which will be introduced to the program in addition to the previous work statements include a reliability assessment and a more formalized quality control program. It is expected that negotiation of this amendment to the contract will be completed in early December.

Other project management efforts included the preparation of test plans and objectives necessary for the component and system testing which was conducted on CSU I-1A and the subsequent PCS I-1 test. Additional effort was expended in the supervision and direction of the CSU I-3 turbo-alternator post-test examinations which have continued throughout the quarter.

Data reduction and analysis has continued on a full-time basis regarding the completion of the CSU I-3 turbo-alternator endurance test, the CSU I-1A performance test, and the initial PCS I-1 system performance test.

TEST RIG DESIGN AND FABRICATION

The auxiliary enclosure including installation of the pumps and associated system test equipment has been completed.

The PCS I-1 system was installed in the test rig. Installation and checkout of the required instrumentation, heaters, and auxiliary equipment have been conducted. Figure 1 (in pocket at end of report) shows the Sunflower PCS I-1 system schematic diagram which lists all supporting equipment and test parameters which are to be measured during system operation.

A hot mercury flushing or cleaning operation was conducted on the PCS system for a period of approximately 116 hours during which time 400 to 600°F liquid mercury was circulated throughout the system and auxiliary equipment. The total flow was filtered to remove any foreign matter which may have entered the system during assembly. During this operation, the various flow control valves, flow meters, thermocouples, and instrumentation were checked to verify satisfactory operation.

Calibration of all instrumentation was completed and system testing initiated. During the first few hours of operation, it was found that at the inlet and discharge pressures extant at the boiler flow control valve, the valve would not perform according to specifications. The flow control valve would operate correctly at design flow, but flow lower than the original design flow was recently adopted. Difficulty was caused by too large an orifice size, a result of lower flow that forced the valve to operate near shut-off and made control of flow impossible. The unit was shut down and the valve is currently being repaired with a new seat and plug of a smaller orifice size. This work will be completed during the first week of

December and system start-up will be executed immediately. Figure 2 is a photograph of some of the control consoles associated with the system testing.

The component test rig was shut down after the 2348 hour CSU I-3 turbo-alternator test. Post test calibrations were conducted on all instrumentation. The rig was then modified by replacing the turbine inlet metering, turbine inlet shut-off, and boiler by-pass control valves. The new valves were physically moved to a location nearer the turbo-alternator which allowed a reduction in the number of guard heaters required on the superheater tubing between the turbo-alternator and the control valves. The other rig malfunctions were repaired and the test rig plumbing was modified to allow deliberate flooding of the turbo-alternator bearing drain cavities. After these changes were completed, turbo-alternator CSU I-1A was installed and a checkout test was conducted.

The CSU I-1A unit test was designed to be a short-term performance test of the turbo-alternator and was designed specifically to subject the unit to conditions which might be imposed upon it by operation in the system. The total test time was 64 hours of continuous operation. A more detailed description is outlined in the turbo-alternator section of this report. After completion of the flushing operation, the turbo-alternator was removed from the test rig and installed in the power conversion system.

POWER CONVERSION SYSTEM

Drawing modifications of the system have continued in order to incorporate additional hardware items that the recent CSU I-3 endurance test indicated to be desirable. These items include corrosion product separators in the bearing and boiler feed lines, additional line heaters for pre-heat control, and instrumentation in various locations which will be needed to gain design information.

The system was subjected to a flushing and pre-conditioning operation which included the following operations. The boiler and condenser were flushed as separate units for periods of eight hours. Then the remainder of the system, with the exception of the turbo-alternator, was connected with the bc and condenser and subjected to a pre-conditioning and flushing operation of approximately 100 hours at temperatures ranging between 400 and 600°F. The system was then drained of liquid mercury and the turbo-alternator and corrosion product separators installed.

Initial system start-up and testing was conducted during the last week of November. During this test, it was found that the boiler flow control valve would not allow control of system flow below approximately 14 ppm. This is close to the system design flow of 13.7 ppm, but due to the predicted limitations of the condenser operation on the system, it is desirable to start with flows as low as 4 ppm.

Successful operation was obtained on the system for a period of slightly over three hours when marginal control of the boiler flow was lost entirely and the system flow increased beyond the capacity of the condenser. This forced a controlled shut down. Subsequent start-ups were accomplished with relative ease; however, inability to control the boiler flow dictated a decision to shut down for modification of the control valve.

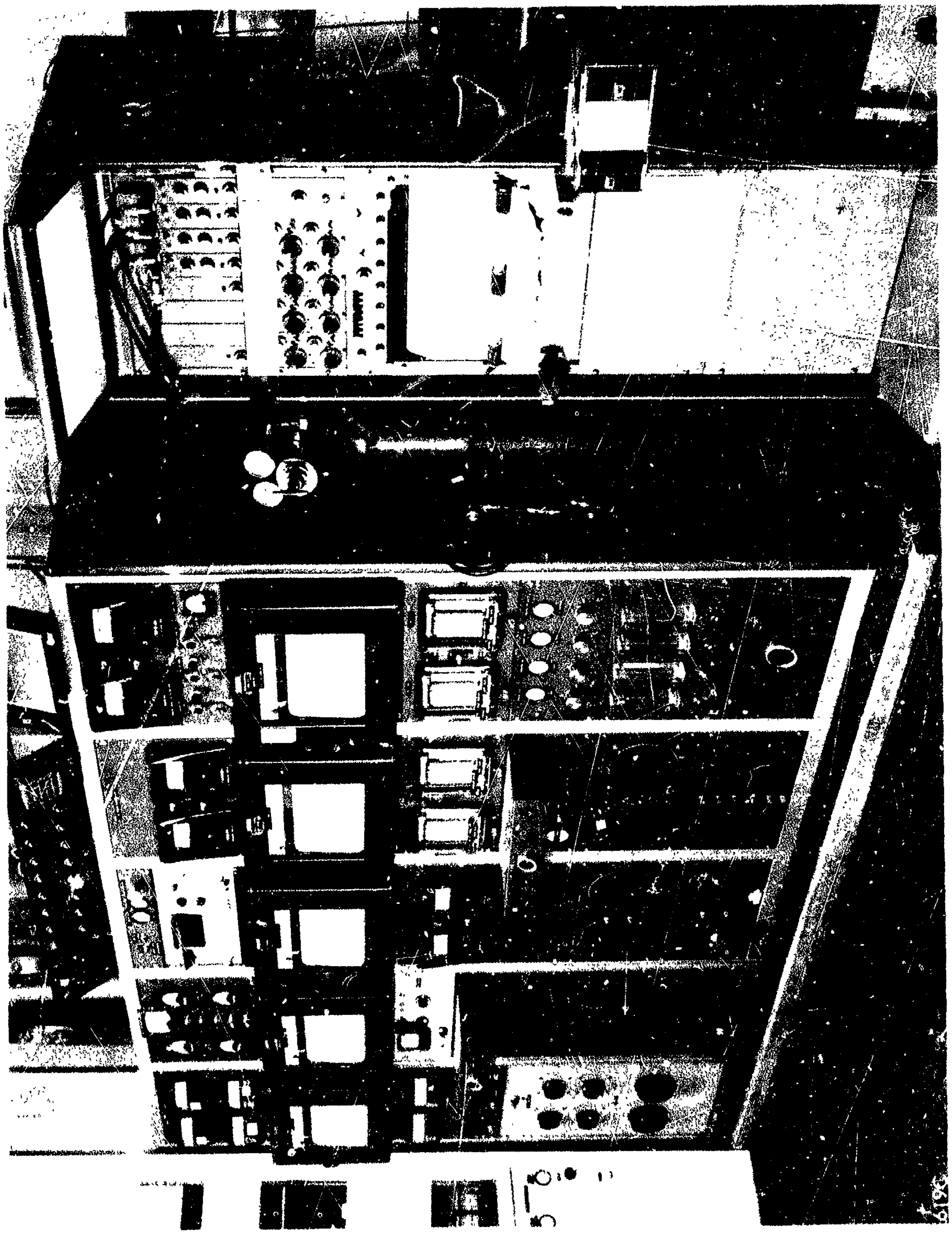


FIGURE 2

While this initial PCS test was not at all satisfactory from the point of view of achieving a controlled exposure of the system to variation of its operational parameters, the results were nevertheless very encouraging. First, even under marginally controlled conditions, the boiler, turbo-alternator, and speed control evidenced excellent stability and basic operational integrity. The lack of flow control, in fact, made this demonstration more impressive by subjecting the system to a wide range of steady-state and transient conditions.

SOLAR COLLECTOR

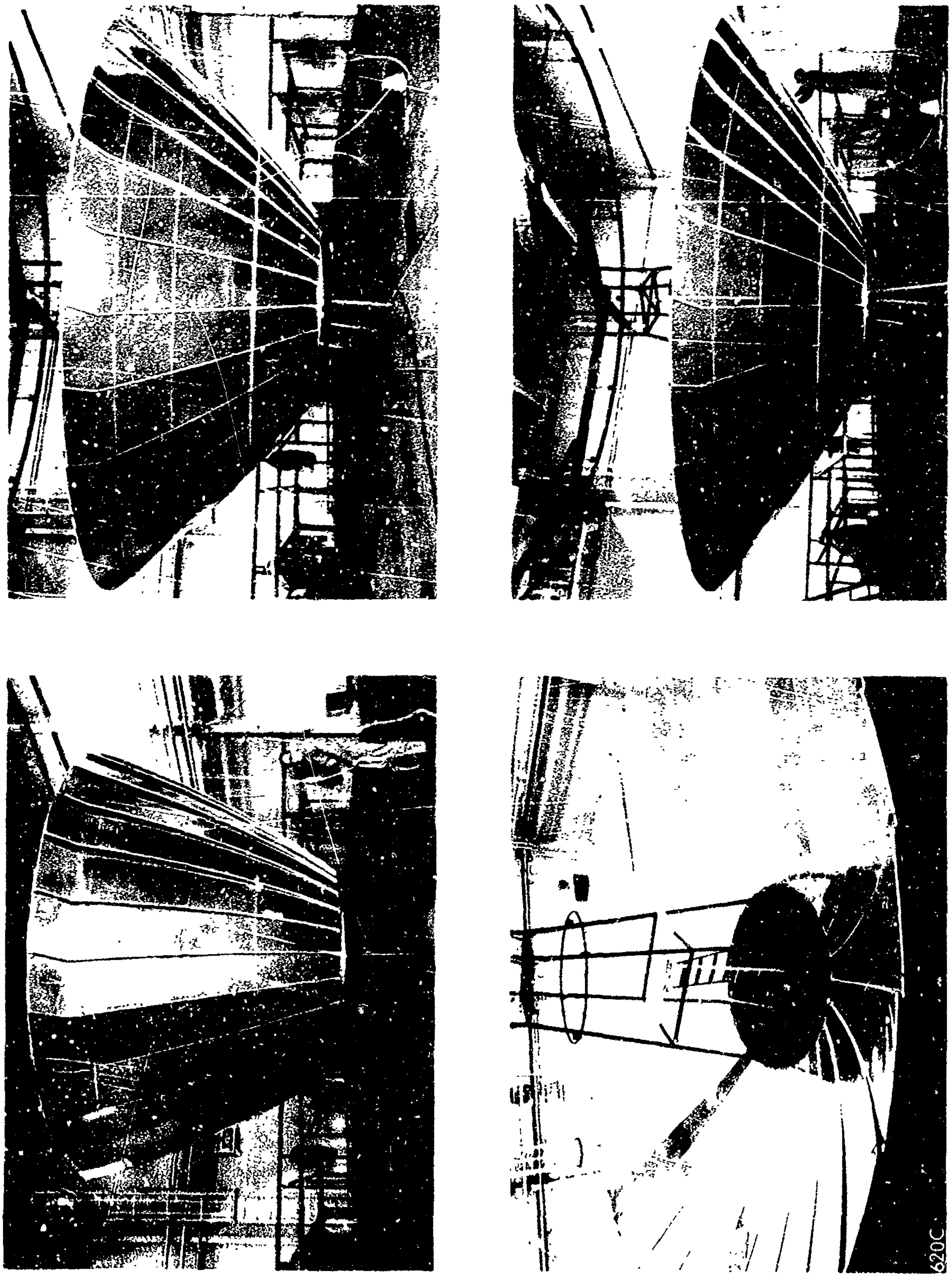
The complete collector, fixture and simulated structure were assembled on the C-210 vibration exciter and preliminary low level scanning tests were conducted on the collector. The initial test consisted of controlling the input to the collector bundle to a 1/2 G input between 20 and 2000 cps. The level was also increased to 1 G and the results of these tests show that a natural frequency of the simulated structure occurs at approximately 70 cps.

The low level survey was conducted primarily to note the various natural frequencies of the combined structures so that an evaluation could be made before proceeding to the higher G level vibration test. The natural frequency of the structure coupled with a cross axis motion of the structure resulted in an input at the collector stacking ring of approximately 18 G's horizontal and 12 G's vertical. This resonance caused local G levels in excess of the collector capability. The analysis of the data indicates that a design modification will be required in the area of the collector stacking ring, and the general approach will be one of isolating that ring from the structure to which it has been attached, as it would be impossible to increase the natural frequency of the structure above the 2000 cps limit of the specification.

The collector assembly was removed from the vibration equipment and returned to the assembly area where an optical inspection was performed on the collector to ascertain if any damage had resulted from the low level survey test. Inspection of the solar collector showed that less than 2/10 of 1% of the collector area was damaged on the vibration equipment, and the majority of the damage observed was due to increase in skin peeling in areas where original peeling had existed. This indicates the need for having complete bonding of the faces in the collector before exposure to vibration testing. Only one sector showed damage in the torsion bar-hinge area. The damage was in the form of skin peeling on the front face and is believed to have been a fabrication quality problem, since none of the other sectors had shown this local peeling.

The rim detents and locks are presently being assembled to the solar collector in order to conduct deployment testing. A deployment harness has been designed which consists of elastic cord bands attached in several locations around the outside diameter of the collector bundle. This design will counteract the weight of the sectors and simulate a zero-gravity environment.

At present the collector cords have been attached and calibration of these restraints is being conducted as shown in Figure 3. Deployment testing of the full collector will be conducted in mid-December. Subsequent modifications to the structure and additional vibration testing will be conducted during the month of January.



CALIBRATION OF SOLAR COLLECTOR DEPLOYMENT HARNESS

FIGURE 3

Single panel testing continued as weather permitted. A series of tests was conducted during November in which flux tests were performed using temperature sensitive paints. Calorimeter tests utilizing various size apertures were also conducted. The single panel testing has shown some conflicting calorimeter efficiencies that depend upon the instrumentation which was used. Additional tests have been conducted to determine the efficiencies of the instrumentation. The indicated efficiencies varied between 50 and 83% on the particular panel used during this test. Reflectivity measurements taken on the single panel had shown that the reflectivity of this particular coating was 84%, indicating the maximum possible efficiency that would be obtainable. Additional tests have been conducted on two of the collector panels. Figure 4 shows the preliminary results from the calorimeter testing.

The design curve is based on a 92% reflectivity; however, the reflectivity attained on the test petals was measured at an average of 86%. This accounts for the portion of losses termed "reflectivity". Other reflectivity measurements are being obtained from samples which weathered with the test petals. These will be averaged for final results.

Evaluation of calorimeter losses, i.e., convection, conduction, and re-radiations is being conducted to seperate losses and obtain values for collector geometric inaccuracies and other performance information.

TURBO-ALTERNATOR

The disassembly of CSU I-3 was continued throughout the quarter. As reported in the previous quarterly progress report, the corrosion product formation build up on the first stage nozzle occurred until the deposited materials were of sufficient size to cause rubbing of the first stage wheel and ultimate failure of the unit. Further inspection has shown other areas where minor corrosion product formation has occurred. These include the second-stage nozzle in the throat areas, and the first and second stage wheels in the blading. In addition to corrosion product formation, some erosion was noted on the pump impeller, on the outside diameter of the alternator rotor where it probably contacted liquid mercury and on the second and third stage turbine wheels which show damage on the leading edge of the wheels. The more severe erosion on the leading edge of the third stage wheel is indicative of the mismatched velocity profiles which occurred from the off-design area of the third stage nozzle. This damage is illustrated in Figure 4.

The actual disassembly of the unit caused some physical damage to portions of the hardware due to the tight fits of the turbine stators. To remove these stators from the housings a forcing action was required and, as a result, damage occurred to the third stage turbine wheel and nozzle sections. The first stage turbine nozzle is presently being analyzed and sectioned to determine the constituents and patterns of the corrosion products. The results will be incorporated in a CSU I-3 test report.

The erosion damage which occurred in the pump impeller has been attributed to the clogging of the jet pump nozzle which occurred throughout the majority of the 2300 hour test. With the nozzle being restricted, the jet centrifugal pump was caused to operate in a cavitation region and therefore the cavitation damage noted on the eye of the impeller is not to be completely unexpected. Post-test component runs of the pump impeller indicate that the

SUNFLOWER COLLECTOR
SOLAR TESTING RESULTS
SINGLE PETAL TEST RIG

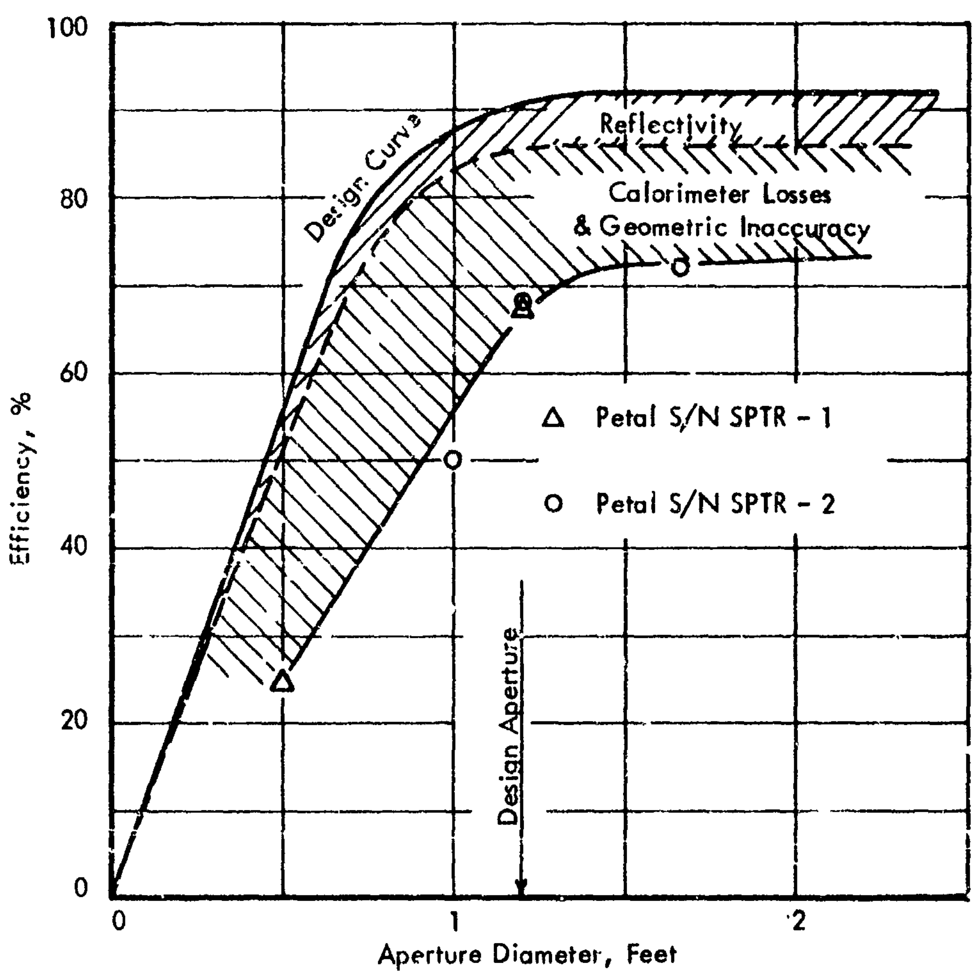
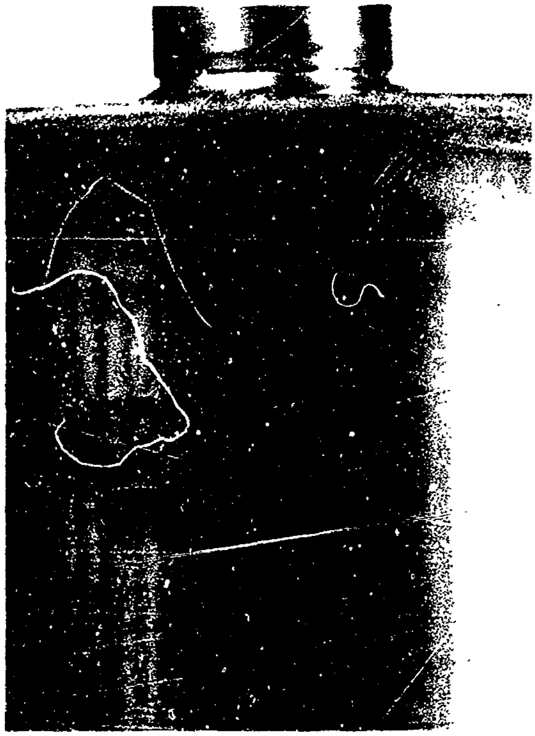


FIGURE 4

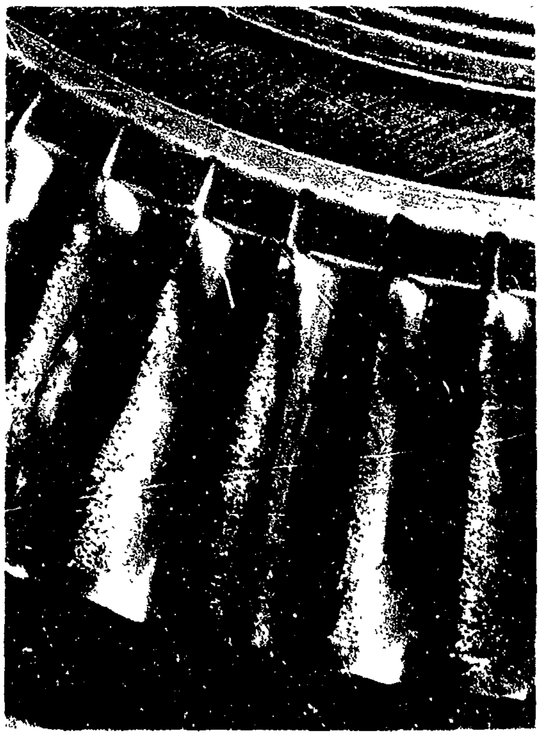
EROSION DAMAGE NOTED DURING 2300 HOUR CSU I-3 TEST

CSU I-3 Mercury Pump Impeller



CSU I-3 Alternator Rotor

CSU I-3 Second Stage Wheel Entrance



CSU I-3 Third Stage Wheel Entrance

FIGURE 5

erosion damage on the impeller has not affected performance of the pump and simulated runs with the jet nozzle supply shut have shown data comparable to that obtained during the CSU I-3 test.

The shutdown of the CSU I-3 prompted a change in the plans for the turbo-alternator unit which was to be devoted to system testing. Instead of being assembled into system testing without a component checkout, the CSU I-1A unit was assembled and installed in the component test rig for a limited performance checkout test.

The significant differences between turbo-alternator unit I-1A and design are relatively minor, but include several significant differences which are listed below:

1. The first stage turbine nozzle area is larger than design by approximately 4%.
2. The third stage nozzle has incorporated "plugs" to correct the nozzle to the desired design value.
3. The prototype alternator housing heater has been installed and will be used throughout the test.
4. The turbine inlet housing heater was redesigned to improve its integrity.
5. A filter was incorporated in the jet pump supply nozzle.
6. Several of the turbine inter-stage labyrinth seal clearances are larger than the designed values due to the fact that this turbo-alternator uses hardware from the original CSU I test. The effects from the large clearances will be minimal, resulting in a slight degradation of turbine performance.

Turbo-alternator CSU I-1A was started October 3, 1962, and successfully survived an erratic start which resulted when the turbine inlet valve was opened above the desired inlet pressure due to a delayed pressure response in the turbine inlet pressure instrumentation.

The speed of the unit increased from zero to 38,000 rpm in a period of six seconds. The speed was subsequently decreased to 20,000 rpm and allowed to stabilize for a period of one hour, after which time the speed was progressively increased in 5000 rpm increments until 40,000 rpm was achieved. The turbine inlet pressure was raised to the design value of 240 psia and the resulting power taken at the watt-meters on the console was 3420 watts. This indicates that the unit design is within the component specifications and very close to its nominal value. Subsequent calibrations of instrumentation on the system test rig have proven that the application of the watt-meters in the component test rig lend themselves to inherent inaccuracies. The voltage taps of the watt-meters were taken near the console rather than close to the ultimate usage point of the power. The line loss which occurred in the approximate 50 foot length of each line resulted in voltage drop and an indicated power loss of 40 to 50 watts per phase. Correction of the watt-meters would therefore raise the total power approximately 80 to 100 watts to a value of 3500 watts.

CSU I-1A was allowed to stabilize at full power and speed for a period of approximately 20 hours after which time the following test plan was initiated:

1. Note the effects on the unit of changing bearing inlet flow temperature $\pm$ 50°F.

2. Note the effects on the operation of the unit in changing alternator coolant flow temperature $\pm$ 50°F.

3. Note the effects of turbine exhaust pressure on power output between the limits of 5.0 and 7.5 psia.

4. Perform a complete pump calibration curve at pump inlet pressures varying between 4 and 6.5 psia.

5. Note the effects of discharging the turbo-alternator bearing flow 12 inches above the package center line, thus causing flooding of the bearing discharge cavities.

The unit successfully completed all of the above objectives. It is interesting to note that little effect was noted on the unit during any of these tests, with the exception of operation with the bearing drains flooded. During the bearing drain test it was noted that when flow was forced to discharge above the package center line, a resulting decrease in performance was noted of approximately 300 watts in power. However, during this test the unit continued to run smoothly and did not exhibit any erratic operation. The decrease in power was expected since flooding of the bearing cavities forces several rotating parts to be submerged in liquid mercury and an increased drag to be encountered.

The results of the test indicate the desirability of incorporating a screw pump seal in the turbine end of the package. To operate the unit under a completely flooded bearing condition, a screw pump seal similar to the seal on the alternator end of the rotating package will be incorporated. When seals of this type are installed on the unit a condition will exist that will permit operation of the unit with pressurized bearing drain cavities. Operation of the unit with pressurized cavities will allow draining of mercury against adverse gravity conditions rather than relying upon fluid dynamics and pressure gradients to transport the liquid to the correct locations. These changes and modifications are to be incorporated in turbo-alternator unit I-2.

Turbo-alternator I-1A was operated through a normal shutdown procedure which was accomplished satisfactorily. Upon complete shutdown of the unit, bearing flow calibrations were made. The unit was protected by inert cover gas while awaiting assembly into the PCS I-1 system. The total elapsed time of this performance test was 64 hours.

The turbo-alternator unit was installed in the PCS I-1 system and instrumentation including pressure gauge, thermocouples, transducers, and accelerometers was installed. The unit was then subjected to flow calibrations of the bearings and eventually underwent initial start-up and a performance testing in the PCS unit.

The programmed start of the PCS system included starting four pounds per minute flow through the turbo-alternator and increasing speed to 30,000 rpm. At this condition the unit was to stabilize before proceeding to higher flows and powers. However, the complete accomplishment of the test plan was not achieved due to the malfunction of the boiler flow control valve. As a result, the unit was operated through two successful starts and stops. The turbo-alternator coupled with the speed control handled with extreme ease. The present status of the turbo-alternator unit is one of awaiting future tests. It is presently inerted with a cover gas. As soon as the boiler control valve can be repaired, additional tests of the system will be completed.

CONDENSER-SUBCOOLER

The condenser-subcooler effort during the reporting quarter has consisted of completion of the analysis of the CSC I-1A test report and continuation of the condenser-subcooler topical report.

The brief testing which was conducted on the PCS system with the condenser installed has confirmed the fact that the condenser operates at a higher than design pressure level for a given flow rate. This condition has been identified as progressive wetting of the condenser wall with mercury. This results in larger drop sizes being formed on the wall and increased vapor velocity is required to carry the drops to the interface chamber. The increased vapor velocity in turn results in a high inlet pressure at the turbine exhaust unless a lower turbine weight flow is utilized.

The limited tests which were conducted on this system did not allow sufficient time to experiment with methods which might be utilized to reduce the turbo-alternator exhaust pressure but, in general, the condenser did operate stabily at a fixed pressure for the duration of time which the unit was run. When the valve malfunctioned, increased weight flow was directed to the turbine and condenser which caused the saturation temperature at the turbine exhaust to rise to a point felt to be marginal and a controlled shutdown was affected. Future tests of the system will determine the extent of condenser compliance to the system specifications of -1 G.

LITHIUM HYDRIDE CONTAINMENT

Construction of a second static temperature test furnace was completed, including the installation of the supporting instrumentation. Fabrication of capsules for a second long-term (2500 hour) cyclic temperature test has been completed. The test was initiated and has completed 930 hours of the 2500-hour duration. A third 2500-hour test has also been started and has presently completed 500 hours of testing. Preparations for the fourth such test have been started. These tests are being conducted in the second static temperature furnace. Table I lists current status of the static temperature test.

The hydrogen atmosphere cyclic temperature test furnace has been modified to allow operation of this furnace at high temperatures in an argon atmosphere.

TABLE I

TABULATION OF STATIC TEMPERATURE TESTING

Test No.	Test Temperature, °F	Scheduled Test Hour	Status
ST-14	1600	200	Complete
ST-14A	1600	200	Complete
ST-15	1600	500	Complete
ST-16	1600	1000	Complete
ST-18	1400	500	Complete
ST-19	1400	1000	Complete
ST-20	1200	200	Capsules 80% Complete
ST-21	1200	500	470 Hours
ST-22	1200	1000	Capsules Complete
ST-23	1000	200	Capsules 80% Complete
ST-24	1000	500	Capsules Complete
ST-25	1000	1000	Capsules 80% Complete

Hydrogen permeability measurements have been completed in the following samples:

1. Copper plated Type 304 stainless steel: Test indicated the permeability to be controlled by a $\sqrt{P}$ law. The measured permeability agreed with calculations based on the permeability of pure copper and Type 304 stainless steel.

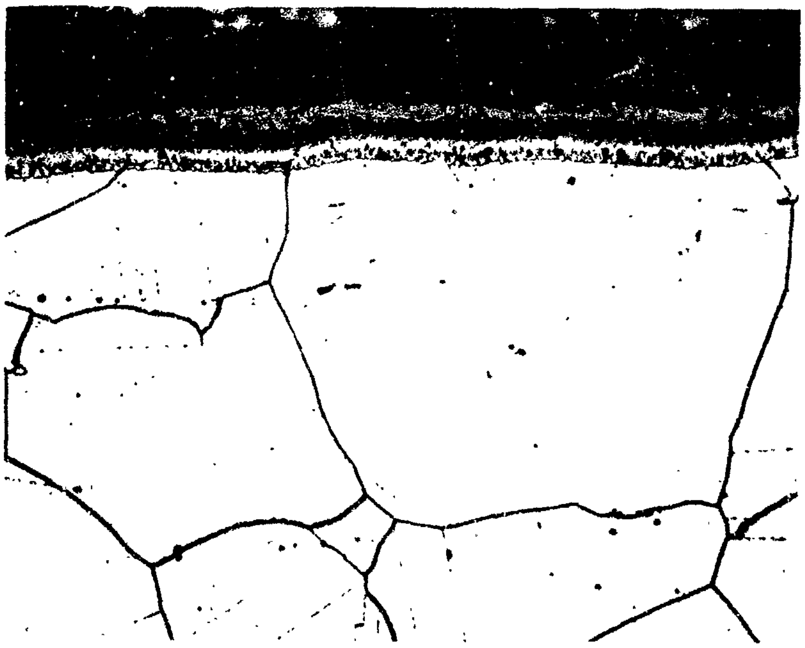
2. Silver plated Type 304 stainless steel: This plating decreased the permeability of hydrogen through the base material. The barrier deteriorated with time due to diffusion of the coating into the base metal.

3. Siliconized Haynes No. 25 alloy: The effectiveness of the barrier decreased as the time and test temperature increased. Deterioration of the coating was related to a variation in cobalt-silicon intermetallics which were produced by the coating operation. The barrier has been determined to be ineffective in reducing hydrogen diffusion.

   The initial test results indicated that the permeability of hydrogen through siliconized Haynes 25 at 1600°F was 1.42×10^{-1} cc/hr-cm^2/mm/atm$^{1/2}$. With increased test time at 1600°F the permeability through the coating continuously increased to 2.45×10^{-1} cc/hr-cm^2/atm$^{1/2}$ after 100 hours. The breakdown in the barrier properties of the coating could be directly correlated to the gross diffusion of silicon from the coating into the base metal. Figure 6 presents the initial appearance of the coating prior to testing. X-ray diffraction indicated that the coating surface consisted of $CoSi_2$ and CoSi types of intermetallics. The exact composition of the coating was difficult to determine because of the complexity of the base Haynes 25 alloy.

   After the completion of the permeability tests (approximately 250 hours) the appearance of the coating was significantly altered (see Figure 7). X-ray diffraction of the coating subsequent to testing showed that the $CoSi_2$ and CoSi type intermetallics were not present and the coating surface consisted primarily of the lower silicon Co_2Si type intermetallic. Although the gross diffusion of the silicon into the base metal is believed to be the primary cause of the coating deterioration, the reason why certain intermetallics (e.g. high silicon intermetallics) are more effective barriers to hydrogen diffusion than those containing lower silicon contents is still a fundamental question which requires additional study.

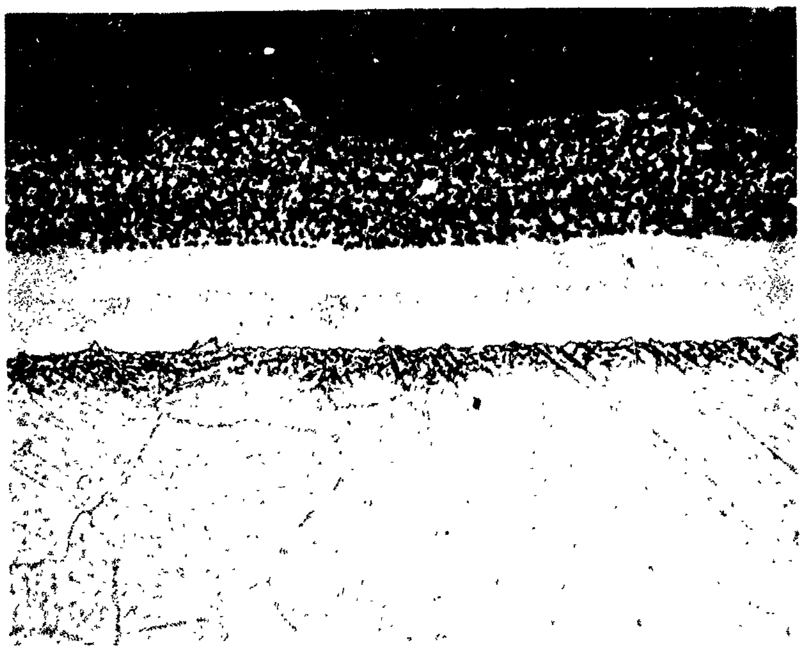
4. Columbium tubing was coated with Cr-Ti-Si. The permeability to hydrogen at 975°F was approximately 3 cc/hr-cm^2-mm/atm$^{1/2}$. This value is nearly 50 times lower than the reported values for pure columbium. However, this diffusion rate is approximately 1000 times greater than the barrier afforded by pure molybdenum. Although additional testing is continuing, the results strongly suggest that the use of columbium in this form would be unsatisfactory for retaining hydrogen in a lithium hydride boiler/heat storage unit.



RDM 6012

SILICON-COATED HAYNES 25 BEFORE PERMEABILITY TESTING,
500X, REFRACTORY METAL ETCH

FIGURE 6



RDM 6011

SILICON-COATED HAYNES 25 AFTER PERMEABILITY TESTING,
500X, REFRACTORY METAL ETCH

FIGURE 7

PERMEABILITY OF HYDROGEN THROUGH VARIOUS MATERIALS

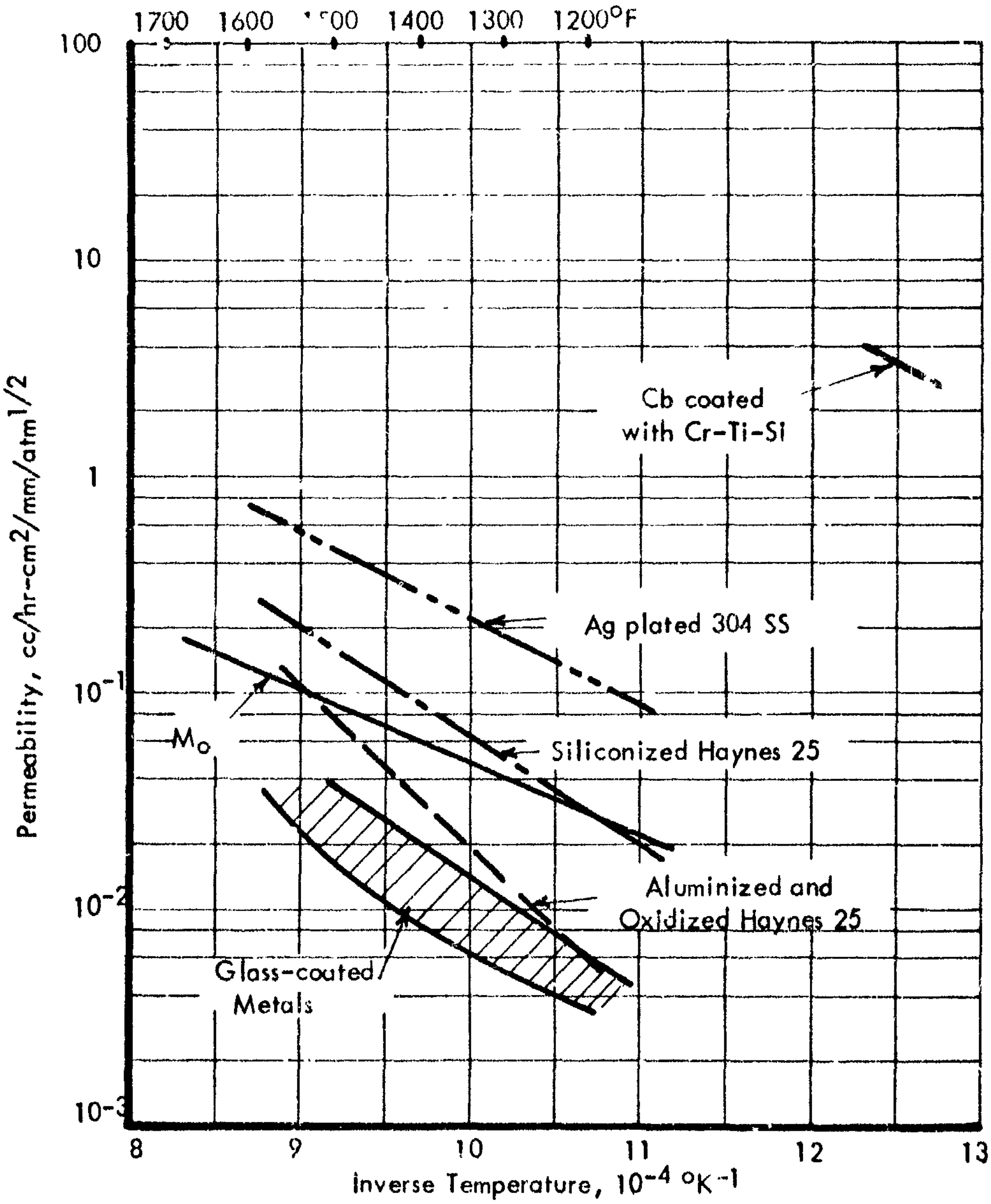


FIGURE 8

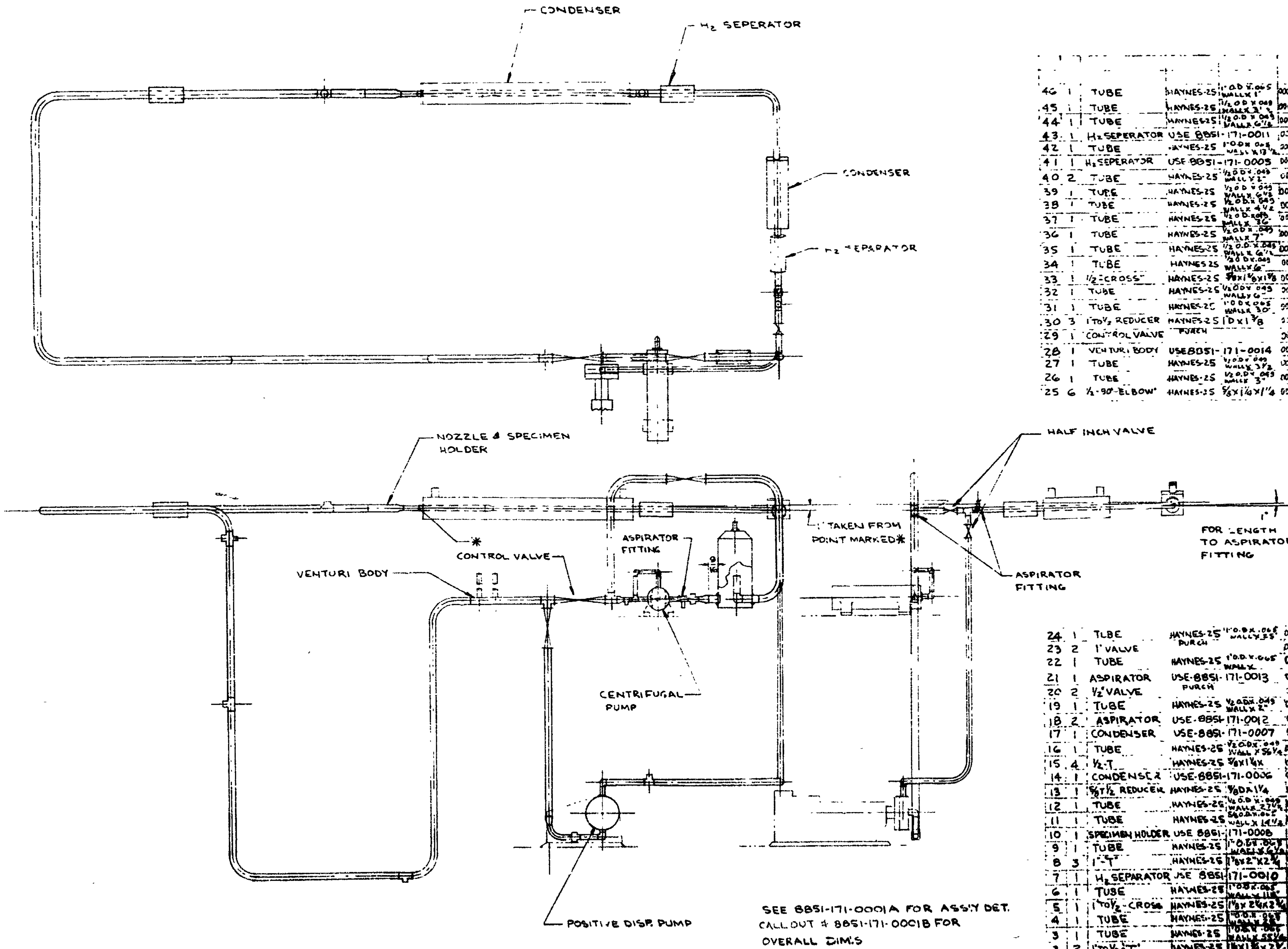
Figure 8 shows the permeability versus inverse temperature for four samples and compares them to the base time material molybdenum. A few additional samples are also included for reference.

MATERIALS

Construction of the workhorse loop has been completed and checks were made for leaks under both pressure and vacuum. Figure 9 shows the details of this loop. Several attempts were made during the reporting period to bring the loop up to operating conditions but various instrumentation malfunctions caused shut down of the loop. This loop, incidentally, is designed to operate unattended and the problems encountered have been "opening" of the high temperature thermocouples which cause actuation of a temperature limiting safety circuit. The thermocouples are now being replaced utilizing a different mounting technique which should alleviate the problem.

Approximately 100 hours of operation have been accumulated at boiling temperatures of 900 to 975°F and at superheat temperatures of 1300 to 1350°F. The longest continuous run was 80 hours. Upon reaching thermal stability conditions, the loop operated very satisfactorily. It is anticipated that replacement of the thermocouples will allow uninterrupted operation and initiation of the centrifugal pump testing.

The corrosion loop work has continued throughout the quarter and is approximately 75% complete. A design change in the loop included replacement of a sharp edged orifice with a nozzle in the high temperature section. The pressure recovery of the nozzle dictates that a throttling valve of Haynes alloy No. 25 will be required and the long delivery schedule of this valve may cause some delay.



46	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 1"	0002
45	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 2 1/2	0002
44	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 6 1/2	0002
43	1	H_2 SEPERATOR	USE 8851-171-0011		0011
42	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 13 1/2	0003
41	1	H_2 SEPERATOR	USE 8851-171-0005		0005
40	2	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 2"	0002
39	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 6 1/2	0002
38	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 4 1/2	0002
37	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 36	0002
36	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 7"	0002
35	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 6 1/2	0002
34	1	TUBE	HAYNES 25	1/2 O.D. X .049 WALL X 6"	0002
33	1	1/2 "CROSS"	HAYNES-25	5/8 X 1 5/8 X 1 5/8	0004
32	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 6	0002
31	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 30"	0002
30	3	1 TO 1/2 REDUCER	HAYNES-25	1 D X 1 7/8	0002
29	1	CONTROL VALVE	PURCH		0001
28	1	VENTURI BODY	USE 8851-171-0014		0014
27	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 3 1/2	0002
26	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 3"	0002
25	6	1/2-90°-ELBOW"	HAYNES-25	5/8 X 1 1/4 X 1 1/4	0004

24	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 25"	0002
23	2	1" VALVE	PURCH		0001
22	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X	0003
21	1	ASPIRATOR	USE-8851-171-0013		0013
20	2	1/2" VALVE	PURCH		0001
19	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 2"	0002
18	2	ASPIRATOR	USE-8851-171-0012		0012
17	1	CONDENSER	USE-8851-171-0007		0007
16	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 56 1/4	0002
15	4	1/2-T	HAYNES-25	5/8 X 1 1/4 X	0004
14	1	CONDENSER	USE-8851-171-0006		0006
13	1	5/8 T 1/2 REDUCER	HAYNES-25	5/8 D X 1 1/4	0002
12	1	TUBE	HAYNES-25	1/2 O.D. X .049 WALL X 27 1/2	0002
11	1	TUBE	HAYNES-25	5/8 O.D. X .062 WALL X 14 1/2	0002
10	1	SPECIMEN HOLDER	USE 8851-171-0008		0008
9	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 6 1/2	0002
8	3	1"-"T"	HAYNES-25	1 1/8 X 2" X 2 1/4	0004
7	1	H_2 SEPARATOR	USE 8851-171-0010		0010
6	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 11"	0002
5	1	1" TO 1/2 - CROSS	HAYNES-25	1 1/8 X 2 1/4 X 2 1/4	0004
4	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X	0002
3	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 55 1/4	0002
2	2	1" TO 1/2 "T"	HAYNES-25	1 1/8 X 1 1/8 X 2 1/4	0004
1	1	TUBE	HAYNES-25	1" O.D. X .065 WALL X 5 A"	0002

ASSEMBLY DETAILS OF WORKHORSE MERCURY LOOP

FIGURE 9

IV. CURRENT PROBLEM AREAS

The system testing conducted thus far has shown that replacement or repair of the boiler flow control valve will be required before additional system testing can be accomplished. To keep the time delay to a minimum, TRW will modify the flow control valve. Before insertion of the valve into the PCS system, a flow calibration test using liquid mercury will be conducted.

The system test confirmed that the condenser operating pressure is higher than the design value and that reduced cycle flow will be required with the CSC I-1A condenser.

V. PLANNED DIRECTION OF EFFORT FOR THE NEXT QUARTER

Performance and endurance testing of turbo-alternator I-3A and I-4 are scheduled to be conducted in the component test booth.

The PCS I-1 system test will be continued in the system test booth.

Solar collector deployment testing of the full-scale paraboloid will be conducted, as will vibration testing of the collector and simulated structure combination.

Operation of the workhorse loop will be continued as soon as the present thermocouple difficulties are corrected. Testing of the hydrogen swallowing capabilities of the jet centrifugal pump will be started.

The forced circulation mercury corrosion loop will be completed and the 5000 hour testing will begin. Materials efforts will consist of evaluation of the lithium hydride test capsules currently undergoing testing.

Work is continuing on completing the Boiler Heat Storage and Rotational Speed Control topicals which have been reviewed by NASA. Other topical reports which will be in process include the condenser-subcooler and solar collector reports.

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